# RZ€ - The new German total merit index expressing breeding impact in Euro

*S. Rensing, S. Kipp and H. Alkhoder*

*Vereinigte Informationssysteme Tierhaltung w.V. (VIT), Heinrich-Schröder-Weg 1, D-27283 Verden, Germany*

## Abstract

Breeding values for Holsteins are expressed in Germany on a relative scale with average 100 and genetic spreading 12. This includes the established total merit index RZG. EBV on relative scale have advantages but an important disadvantage is that they do not show the economic impact of selection decisions directly. The new, additional total merit index RZ€ (spell RZ Euro) is therefore expressed in Euro margin. The margin refers to the total margin realized by a cow during her lifetime of about three years in comparison to the basis that are 4 – 6 years old cows. Included in RZ€ are the evaluated traits with their economic impact based on current margin calculations. Economic weights purely follow transparent margin calculations without any additional aspects from a breeding policy point of view. In this aspect the RZ€ is unique compared to other internationally used total merit indices.

*Keywords: Total merit, breeding index, economic based, Holstein .*

## Introduction

In Germany estimated breeding values (**EBV**) for dairy breeds are expressed as relative breeding values on a scale with average 100 and a genetic standard deviation of 12. Only exceptions are the EBV for milk production traits that are expressed on the phenotypic scale (kg, %), respectively. The relative scale is used for single traits but also for all indices including the total merit index (**TMI**) RZG, established in 1996. The advantage of a relative scale is that EBV can be compared directly across traits and indices in the sense that it is known where the animal ranks within the trait/index (e.g., +2 standard deviation >= rank 97,5%). The disadvantage of a relative scale is that differences on the phenotypic scale between animals are not directly visible. For the total merit index this means that the economic impact of higher or lower RZG is not clear. Therefore, there was an increasing demand of farmers and industry to have an additional TMI on an economic scale i.e., in Euro (**€**) to clearer indicate the often-underestimated economic impact of selection for animals with higher or lower TMI, the RZ€. For Holstein, the RZ€ was introduced in August 2020. For the other dairy breeds RZ€ is not available because the direct health traits as important part of RZ€ are so far only available for Holstein.

## Method

To calculate the economic impact per relative point of published EBV (resp. per genetic standard deviation) two basic figures are needed:

- phenotypic units that equal ±1 relative point of published EBV.
- margin per trait unit on the phenotypic scale (e.g. per case).

## Phenotypic units per relative point EBV

Due to technical reasons phenotypes used in genetic evaluation are often different compared to traits/scales used for economic calculations in dairy farms. Examples are longevity or calving ease traits. In genetic evaluation for longevity not the total productive lifespan in time units is used, but survival as 0/1 for certain time periods in a multi-lactation-model. Calving ease uses scores for ease of calving on a 1to 4 scale that is different to percentage of difficult calvings. Therefore, the genetic standard deviations from the evaluation models cannot be used for economic calculations. According to that the genetic standard deviations on the phenotypic scale were derived from the observed daughter differences between top and bottom 25% of daughter proven Holstein AI bulls from the latest three full proven bull birth years. These were AI bulls born 2008 to 2010 (for the trait longevity the bulls were born 2003 to 2005). Only daughters that had the chance to show performance over three lactations were included (for longevity to survive eight years). For most traits the difference between the top and bottom 25% of bulls was in the range of 20 to27 relative points of EBV i.e. about two genetic standard deviations. The daughter difference between the two bull groups were standardized to 24 points so that the daughter difference represents one genetic standard deviation (50% from sire). Table 1 shows the results i.e. what difference on the phenotypic scale equals 12 points or 1 genetic standard deviation of relative breeding value.

In the German genetic evaluation system 13 individual health traits or disorders are included, but breeding values are published for four traits/indices only. The EBV for mastitis resistance (RZudderfit) is the only one health trait comparable to the single

*Table 1. Description of phenotypic units corresponding to a genetic standard deviation $S_g$ (12 points) for each trait/EBV.*

| Relative EBV | Daughter trait | Daughter phenotype (Ø all lact.) | Realized $S_g$ |
|---|---|---|---|
| RZS | Cell count (k/ml) | 218 | 83[1] |
| RZN | Longevity (days) | 1115 | 259 |
| 1st-to-last heifer | 1st-to-last heifer (days) | 31.3 | 6.2 |
| NR heifer | NR heifer (%) | 72.0 | 5.0 |
| calv.-1st | Calv.-1st (days) | 84.2 | 9.0 |
| 1st-to-last cows | 1st-to-last cows (days) | 51.5 | 10.1 |
| NR cows | NR cows (%) | 55.7 | 6.3 |
| CE direct | Difficult calvings (%) | 3.5 | 2.0[1] |
| SB direct | Still born calves (%) | 5.8 | 2.4[1] |
| CE daughter | Difficult calvings (%) | 3.2 | 1.7[1] |
| SB daughter | Still born calves (%) | 5.8 | 3.1[1] |
| Dairy type | Dairy type (scores) | 81.9 | 0.9 |
| Body | Body (scores) | 82.1 | 1.1 |
| Feet & legs | Feet & legs (scores) | 80.6 | 1.0 |
| Udder | Udder (scores) | 81.2 | 1.0 |
| RZD | Milking speed (kg/min.) | 2.42 | 0.40 |
| RZcalffit | Young stock survival (15 mo.) % | 93.0 | 4.4[1] |

[1]Spreading on phenotypic scale is skewed.

*Table 2. Description of phenotypic units of each health trait corresponding to a genetic standard deviation (12 points) of its corresponding health index EBV.*

| Relative EBV | Daughter trait | Daughter phenotype (Ø all lact.) | Realized $S_g$ |
|---|---|---|---|
| RZudderfit | Mastitis % | 25.6 | 12.0[1] |
| RZhoof | Mortellaro % | 24.1[1] | 12.0[1] |
| | Sole ulcer % | 15.1[1] | 13.2[1] |
| | Digital phlegmon % | 8.4[1] | 10.8[1] |
| | White line defect % | 7.6[1] | 6.4[1] |
| | Laminitis % | 6.8[1] | 3.5[1] |
| | Tylom % | 5.1[1] | 4.4[1] |
| RZrepro | Ovarian cycle disorders % | 19.7[1] | 11.5[1] |
| | Metritis % | 13.1[1] | 7.4[1] |
| | Retained placenta % | 7.5[1] | 4.9[1] |
| RZmetabol | Displaced abomasum % | 1.4[1] | 3.1[1] |
| | Milk fever % | 1.9[1] | 1.7[1] |
| | Ketosis % | 3.1[1] | 2.4[1] |

[1]Spreading on phenotypic scale is skewed.

traits in table 1. Because the economic calculations should be based on published EBV, the impact of one genetic standard deviation of published health trait indices for hoof health (RZhoof), metabolic stability (RZmetabol) and resistance to reproduction disorders (RZrepro) were derived as shown in table 2. Differences in these published health indices have impact on three to six underlying traits economic weight can be calculated for. Within each health trait index the included single traits are positively correlated so that improving genetic level for the health index by one genetic standard deviation improves the level for all included traits at the same time as given in table 2.

## Margin per trait unit

The margin per trait unit is calculated as direct marginal cost minus direct marginal return under average German production conditions keeping all other traits constant (ceteris paribus condition). It is important to consider only direct economic impact but not indirect impact via other traits included in RZ€. For the example of mastitis resistance, the direct economic impact of one unit more mastitis (= one additional case of mastitis) are the extra costs for treatment (veterinarian, drugs, labor) and produced milk that is not tradable due to antibiotic treatment. Costs for extra culling of cows with severe mastitis is not considered because this is included in economic impact of longevity. EBV longevity is based on all involuntary culling including culling due to mastitis. By exclusively considering the direct costs and returns of each trait double counting of economic effects is avoided. The first column in table 3 gives the calculated margins per trait unit.

Genetic differences for somatic cell count and conformation traits have only very limited economic impact and therefore are not included in RZ€. Somatic cell count is mainly an indicator trait for mastitis resistance that is included in RZ€. Under ceteris paribus condition (same incidence rate of mastitis) differences in cell count have no economic impact on farm level. Greater 99% of all produced bulk milk meats the threshold of 400,000 cells/ml that would lead to restrictions in milk sale. The importance of conformation traits in dairy breeding practice is based on expected indirect effects via other functional traits (longevity, fertility, calving, health) that are included already with their direct economic impact in RZ€. Conformation traits have a direct economic impact when selling breeding animals because the breeding cattle market values animals with better conformation. Even though German Holstein farmers sell relative to many other countries more breeding heifers (e.g. per year 80,000 German Holstein heifers exported) the absolute number of sold heifers per cow and lifetime is limited to <0.2. This leads to a direct economic impact of conformation traits for an average farm of only about 0.5% relative weight in RZ€. More details on the economic calculations for all traits can be found on www.vit.de (publications – 2020 – The new RZ€).

## Economic impact per cow lifetime

The focus of dairy farmers making selection decisions on the base of EBV is the (economic) superiority of the selected female resp. the daughters of the selected bull. Therefore, the RZ€ is the sum of the economic impact for all traits based on the entire productive lifespan of a cow. The average productive life of a German Holstein cow was assumed with a productive life of about 1100 days (3,01 years) giving birth to three calves and completing 2,75 lactations with average 360 milking days. Based on these assumptions and the genetic standard deviations from table 1 and 2 the economic impact of one relative point EBV per cow lifetime was calculated (see table 3).

For every animal and trait € margin is calculated as (relative) points EBV (deviation from 100) multiplied with economic impact per (relative) point EBV and lifetime. The sum of all trait margins is the total merit in Euro = RZ€. Because the base for all EBV are 4 to 6 year old cows (= 100, representing active cow population) the RZ€ of a female expresses the difference in margin she will realize in average during her lifetime compared to an average cow. The standard deviation of RZ€ is about 535 € and top young genomic females and bulls reach up to almost +3,000 RZ€.

From the ratio of the margins per genetic standard deviation and lifetime the relative weights of the traits and trait complexes can be calculated. In RZ€ the milk production traits have 41% weight, followed by longevity with 27% and direct health traits with 16%. Fertility traits sum up to 7%, young stock survival has 6% and calving traits 3% weight (see table 4).

## Selection response

The correlation of the new TMI RZ€ with the established TMI RZG is high with 0.97. This even though the RZG includes 15% conformation traits and the ratio of weights included

*Table 3. Margin per trait unit and margin per point relative EBV and lifetime.*

| EBV trait | € per unit resp. per case | $S_g$ | €/$S_g$ per lifetime | €/EBV unit+life |
|---|---|---|---|---|
| Fat (kg) | 2.56 | 25.1 | 197.72 | 7.88 |
| Protein (kg) | 4.09 | 19.7 | 248.76 | 12.56 |
| Lactose in F/P free milk (kg)[1)] | -0.024 | 690 | -51.13 | -0.07 |
| RZN/Herdlife (day) | 1.00 | 259 | 258.69 | 21.56 |
| Calving-to-first (day) [2)] | 0.33 | 9.0 | 6.05 | 0.50 |
| First-to-last-insemination heifers (day) | 1.67 | 6.2 | 10.35 | 0.86 |
| First-to-last-insemination cows (day) | 3.67 | 10.1 | 52.06 | 4.34 |
| Stillbirth rate maternal | 137.5 | 3.1 | 12.81 | 1.07 |
| Stillbirth rate direct | 137.5 | 2.4 | 9.87 | 0.82 |
| Calving ease maternal | 59.4 | 1.7 | 4.03 | 0.34 |
| Calving ease direct | 59.4 | 2.0 | 5.03 | 0.42 |
| RZudderfit | 186.0 | 12.0 | 61.39 | 5.12 |
| RZhoof | 32-74 | 4-13 | 30.13 | 2.51 |
| RZrepro | 28-100 | 5-12 | 17.10 | 1.43 |
| RZmetabol | 131-289 | 2-3 | 39.86 | 3.32 |
| RZcalffit (young stock survival) | 449.7 | 4.4 | 54.61 | 4.55 |

*Table 4. Relative weight of traits and trait complexes in RZ€.*

| EBV trait | €/$S_g$ per lifetime | Resulting weights (%) | | |
|---|---|---|---|---|
| Fat (kg) | 197.72 | 20.7 | 41 | Milk production traits |
| Protein (kg) | 248.76 | 26,0 | | |
| Lactose in F/P free milk (kg)1) | -51.13 | -5.3 | | |
| RZN/Herdlife (day) | 258.69 | 27.0 | 27 | Productive life |
| Calving-to-first (day) 2) | 6.05 | 1.1 | 7 | Daughter fertility |
| First-to-last-ins. heifers (day) | 10.35 | 0.6 | | |
| First-to-last-ins.cows (day) | 52.06 | 5.4 | | |
| Stillbirth rate maternal | 12.81 | 1.3 | 3 | Calving traits |
| Stillbirth rate direct | 9.87 | 1.0 | | |
| Calving ease maternal | 4.03 | 0.4 | | |
| Calving ease direct | 5.03 | 0.5 | | |
| RZudderfit | 61.39 | 6.4 | 16 | Health traits |
| RZhoof | 30.13 | 3.1 | | |
| RZrepro | 17.10 | 1.8 | | |
| RZmetabol | 39.86 | 4.2 | | |
| RZcalffit | 54.61 | 5.7 | 6 | Young stock survival |

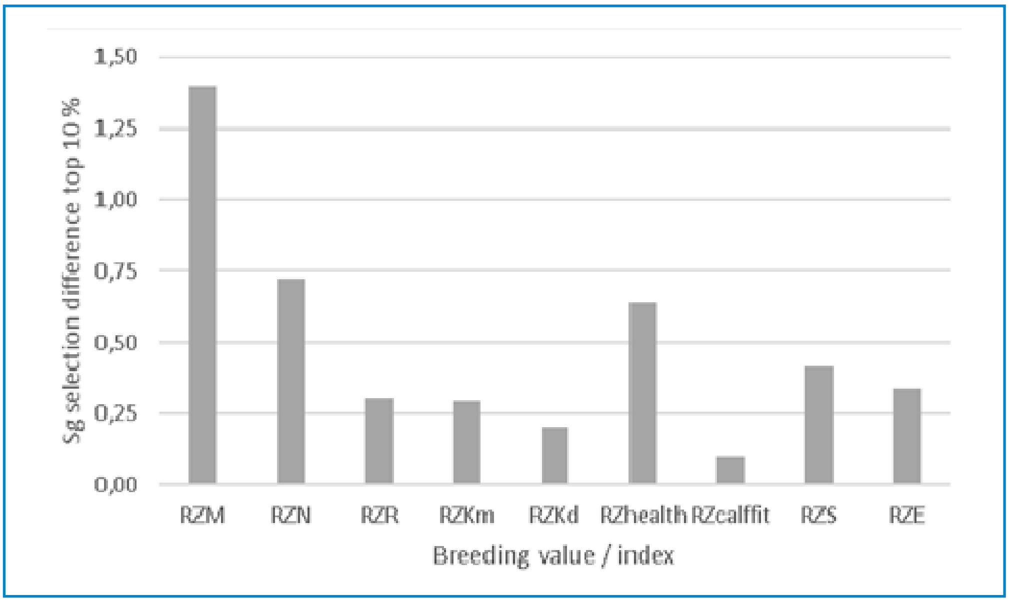


*Figure 1: Selection response selecting for RZ€ (selection difference top 10% of 256,352 females from herd genotyping born 2019+2020, gEBV 04-2021). RZM=index milk production traits, RZN= relative EBV longevity, RZR= daughter fertility index, RZKm/d=calving trait index maternal/direct, RZhealth= total health index, RZcalffit= relative EBV young stock survival, RZS= relative EBV somatic call score, RZE= overall conformation index*

in both TMI is partly different (for composition of RZG see *www.vit.de* - description of breeding values). The expected selection response for selection by RZ€ overall follows the weights for the trait complexes. The expected progress for traits longevity, direct health, fertility, and calving traits is slightly higher compared to the relative weight in RZ€ because these traits have significant positive genetic correlations among each other creating additional indirect selection response. Expected progress in young stock survival is small compared to e.g. fertility traits with comparable weight in RZ€. Young stock survival has no correlation to longevity and health traits of cows.

The importance of conformation traits in farmers selection decisions was already mentioned. Therefore, a concern of farmers regarding selection by RZ€ is the selection response for conformation and for somatic cell count. Even though not included directly in RZ€ there can be expected significant positive indirect selection response for overall conformation by selecting for RZ€ (see figure 1). Overall feed and legs and udder are positively correlated to longevity and direct health traits. Dairy type is correlated to milk production. The indirect selection response for overall conformation by selection for RZ€ equals almost two-thirds of the response selecting for RZG including 15% conformation traits. For somatic cell count the same good selection response is expected as in former times for RZG with 7% direct weight for somatic cell count but no mastitis resistance. This could be expected because now mastitis resistance has 6.4% weight and genetic correlation to somatic cell count is high.

## Summary and outlook

The new and additional TMI for Holsteins RZ€ shows economic impact of selection decisions directly because of the scale € margin per lifetime. The composition follows strictly economic calculations without additional aspects from breeding politics. This is different to most other TMI that e.g. mostly include conformation traits without a true calculation on (direct) economic impact of conformation traits.

Correlation to established TMI RZG including conformation and weighting of trait complexes partially based on breeding policy aspects is high. Nevertheless, impact of RZ€ should not be underestimated. The scale € margin compared to an average cow can make Holstein dairy farmers more aware of the big impact on economy of genetics and selection decisions. Especially the growing number of Holstein dairy farmers that use herd genotyping for selecting their females experience how big the differences in EBV among their animals are and how good prediction of performance differences by genomic EBV is. With this information they can comprehend those differences in RZ€ give a realistic picture of the economic differences based on genetics between animals and how much extra margin is to gain following a strict economic breeding goal.

Finally, the RZ€ shows that an economically based breeding goal must not be in contradiction with animal health and the expectation of the society. Health traits including fertility, calving and longevity get 59% weight in the breeding goal because of economic reasons and breeding goal is no longer dominated by milk production traits and conformation.